Rocky Mountains Southwest Great Plains

Research Note RM-460

November 1985

USDA Forest Service
Rocky Mountain Forest and Range Experiment Station

Vertical Spread of Dwarf Mistletoe in Thinned Ponderosa Pine in Arizona

Frank G. Hawksworth and Brian W. Geils[1]

Upward rate of spread of Southwestern dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum*) in *Pinus ponderosa* was measured in an even-aged, 60-year-old stand near Flagstaff, Ariz. Upward rate of mistletoe spread in 343 trees averaged 10 cm per year over a 6-year period. This was about 2/3 the height growth rate of the same trees. No significant relationship was found between vertical spread of mistletoe and site index or thinning intensity.

Keywords: Dwarf mistletoe, intensification, tree diseases.

The rate of upward spread of dwarf mistletoes (*Arceuthobium*) is important in even-aged stands, because this rate, in comparison to tree height growth, determines how much of the tree's crown will become infected. The effects of dwarf mistletoes on height and diameter growth of a tree depend on the proportion of the crown infected (Hawksworth 1961).

Little research has been done on the upward spread of dwarf mistletoes, and the few data reported are from different host-parasite combinations and vary greatly (from 8 to 65 cm per year) (table 1). Most of the previous data are based on upward spread in inoculated trees (Hawksworth 1969, Scharpf and Parmeter 1976, Wicker and Wells 1983); but Richardson and Van der Kamp (1972) obtained their estimates by dissecting trees and aging individual infections at various heights in the sample trees. Strand's (1973) estimate was based on deposition of mistletoe seeds in relation to female mistletoe plants. No vertical spread data have been reported for Southwestern dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum* (Engelm.) Hawksw. & Wiens), the most serious pathogen of ponderosa pine (*Pinus ponderosa* var. *scopulorum* Engelm.) in the Southwest.

The objectives of this study were to obtain preliminary estimates of the upward rate of spread of Southwestern dwarf mistletoe and to determine if it is related to site index and stand density.

[1]*The authors are Research Plant Pathologists at the Rocky Mountain Forest and Range Experiment Station. Station Headquarters is in Fort Collins, in cooperation with Colorado State University.*

Methods

Twenty-four permanent plots were established in 1977, in a 60-year-old, even-aged ponderosa pine stand in the Fort Valley Experimental Forest near Flagstaff, Ariz. The area is in the ponderosa pine/Arizona fescue habitat type (Hanks et al. 1983). The study was established primarily to determine the effects of dwarf mistletoe on diameter, height, and volume growth in relation to intensity of infection and level of thinning. For each tree, the following data were recorded: diameter (to nearest 0.25 cm), height (to nearest 0.3 m by use of a height pole), dwarf mistletoe rating (DMR) (Hawksworth 1977), and height of the highest visible mistletoe plant.

The plot size, which varied with stand density, ranged from 0.07 to 0.16 ha; but each plot contained at least 200 trees berore thinning. Site index, based on age at breast height of 100 years (Minor 1964) ranged from 17 to 25 m.

Plots were selected with four intensities of mistletoe infection:

1. None.
2. Very light (average DMR 0.06–0.13, 4–10% of trees infected).
3. Light (average DMR 0.25–0.87, 19–45% of trees infected).
4. Moderate (average DMR 1.01–1.65, 50–62% of trees infected).

The six plots in each infection class were thinned—two to growing stock level 60, two to 80, and two to 100 (Myers 1974). The plots were remeasured in 1983, there-

Table 1.—Summary of data on upward spread of dwarf mistletoes.

Arceuthobium	Host	Upward spread (cm per year)	Basis no. trees	Reference
A. campylopodum	Ponderosa pine	10	(not given)	Graham 1967
	" "	8	(not given)	Strand 1973
A. occidentale	Digger pine	61	5	Hawksworth 1969
A. tsugense	Western hemlock	30 (dense stands)	3	Richardson and Van der Kamp 1972
		65 (open stands)	12	" "
A. abietinum	Red and white fir	8	26	Scharpf and Parmeter 1976
A. laricis	Western larch	24	85	Wicker and Wells 1983
A. vaginatum ssp. *cryptopodum*	Ponderosa pine	10	343	This study

by providing data for six growing seasons. All 343 trees that were infected in 1977 and 1983 were analyzed.

Results

A summary of the change in height of the highest visible mistletoe plants between 1977 and 1983, and tree height growth during this period is given in table 2. Upward spread of mistletoe averaged 10.2 ± 1.6 cm per year (95% confidence interval) and ranged from −41 to +61 cm per year. About one-third of the trees showed no change in the 6-year period. Height of highest mistletoe was lower in 1983 than in 1977 in about 8% of the trees, because plants present in 1977 were killed by shading or feeding by Abert squirrels.

Height growth of the same trees during the 6-year period was 14.8 ± 0.9 cm per year, or about 50% greater than the mean upward spread rate of mistletoe. A few trees showed a loss in height because snow broke the tops.

Analyses show no significant relationship between vertical spread of mistletoe or tree height with site index or intensity of thinning. Presumably, the 6-year period, when the trees showed an initial response to thinning, was too short to provide a critical test of these relationships. There was a slight trend for a faster rate of upward spread of mistletoe in trees with higher infection ratings; but the relationship was difficult to quantify, because most trees in the highest infection classes (5 and 6) were removed in thinning.

Discussion

The change in highest visible mistletoe, as used in this study, represents appearance of latent infections and new infections. Because the latency period from infection to production of shoots for this dwarf mistletoe is 3 to 5 years (Hawksworth 1961), probably most of the apparent height increase was from latent infection. The 10 cm per year upward spread is comparable to that reported for a different dwarf mistletoe on ponderosa pine in the Pacific Northwest (Graham 1967, Strand 1973).

The degree of damage is related to the proportion of crown infected; and generally, no significant effect on height or diameter growth is detectable until mistletoe reaches the upper half of the crown. For example, Scharpf and Parmeter (1976) showed that upward spread

Table 2.—Annual vertical spread of dwarf mistletoe and tree height growth, 1977–1983.

6-year height difference (cm)	Vertical spread of mistletoe		Height growth of host tree	
	Number of trees	Percent	Number of trees	Percent
+ 45 to 61	13	3.8	–	–
+ 30 to 45	33	9.6	25	7.3
+ 15 to 30	74	21.6	166	48.4
> 0 to + 15	77	22.4	129	37.6
None	118	34.4	21	6.1
< 0 to − 15	20	5.8	2	0.6
− 15 to 20	6	1.7	–	–
− 30 to 45	2	0.6	–	–
Total	343	100.0	343	100.0
Mean and 95% confidence interval (cm)	10.2 ± 1.6		14.8 ± 0.9	

of dwarf mistletoe in young white and red firs was about 1/4 that of tree height growth. Thus, a relative proportion of infected crown decreases until tree height growth rate eventually declines.

The lack of a relationship between vertical spread of mistletoe and site index in this study may be explained by the relatively narrow range of sites present (17 to 25 m) and the short period of time between readings (6 years). Subsequent examination of these plots, and similar plots in Colorado, should permit clearer definition of the relationships between upward spread of mistletoe and site index, mistletoe intensity, and stand density in ponderosa pine.

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